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Effect of titanium in $LiNbO_3$ on domain growth during *e*-beam writing

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Lithium niobate ($LiNbO_3$) is a basic material for optical integrated circuits of quantum photonics. Periodic domain structures in combination with nonlinear optical waveguide layers on lithium niobate make it possible to realize with high efficiency quasi-phase-matching (QPM) radiation conversion. The e-beam writing of domains is an alternative approach of non-contact creation of periodical domain structures and provides a possibility to fabricate domains on the non-polar surfaces of $LiNbO_3$. In addition, this non-polar geometry of *e*-beam writing is accessible for 3D characterization of the created domains [1].

We present our results on domain growth investigation in titanium doped $LiNbO_3$ crystals. The early observed specificity of domain emerging in Ti:$LiNbO_3$ waveguides [2, 3] has revealed necessity of more detailed understanding of the titanium influence on the domains emerging by *e*-beam writing.

The samples under study were optically polished $LiNbO_3$ plates of non-polar orientation. The following compositions were investigated and compared: a nominally pure $LiNbO_3$ of congruent composition (CLN); $LiNbO_3$ doped with 0.5 mol.% TiO_2 (CLN-0.5Ti); and Ti:$LiNbO_3$ waveguide, obtained by high-temperature titanium diffusion. Near the Ti: $LiNbO_3$ surface a concentration of titanium was ~ 7.6 at.%, and then C_{Ti} gradually decreased to 0.5-0.8 at.% in 4-5 μm depth.

The *e*-beam writing of single domains and periodical gratings of planar type was carried out at the different SEM accelerating voltages. A comprehensive investigation of individual domains and periodical structures was performed by using chemical etching and the nondestructive low voltage SEM and SHG microscopy. Three-dimensional (3D) structure of the planar domain gratings in Ti:$LiNbO_3$ waveguide was observed depending on the e-beam writing conditions. The features of domain growth on non-polar Y cuts in CLN, CLN-0.5Ti and in the waveguide Ti:$LiNbO_3$ were investigated. The differences revealed in the domain sizes as well in the domain structure characteristics of upper and bottom of the domain gratings are discussed in the framework of the current model of intrinsic defect structure of $LiNbO_3$ and an increase of conductivity along the Ti:$LiNbO_3$ depth related to the C_{Ti} variations.

The results obtained show ways to match the conditions of *e*-beam irradiations to the waveguide thickness in order to optimize the grating position, uniformity of domains and waveguide quasi-phase-matching SHG [4].

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